are critical for its preparation at pressures from 3 to 8 GPa is possible. This indicates a broadening of its region of stability with pressure.

We note that quenching from a $Au_{0.77}Si_{0.23}$ melt at p = 3 GPa with a cooling rate of 600°K/sec leads to formation of a melt whose x-ray pattern (Fig. 2) has characteristic features suggesting the presence of a phase different from that already mentioned above in a mixture with an x-ray amorphous alloy. The position of the first peak ($2\theta \approx 40°$) agrees with data on the metallic glass in this system for the composition with 25 at. % Si, $\sin\theta/\lambda = 0.22$ [10], which was prepared with substantially higher cooling rates, 10^6-10^8 °K/sec [1].

CONCLUSIONS

Pressure lowers the critical cooling rates required for formation of metastable phases and metallic glasses in the Au—Si system. However, a broadening of the stability region of the crystalline $Au_{0.77}Si_{0.23}$ phase on the T—p—x diagram substantially changes the thermodynamic and kinetic conditions for preparation of amorphous phases. Amorphous phases are not formed at higher pressure in the range of cooling rates indicated above.

LITERATURE CITED

1. T. R. Anantharaman, H. L. Luo, and W. Klement, Jr., "Formation of new intermetallic phases in binary eutectic systems by drastic undercooling of the melt," Nature (London), 210, No. 5040, 1040-1041 (1966).
2. C. Suryanarayana and T. R. Anantharaman, "On the crystal structure of a non-equilibrium phase in the gold—silicon system," Mater. Sci. Eng., 13, No. 2, 73 (1974).
3. P. Predecki, B. C. Giessen, and N. J. Grant, "New metastable alloy phases of gold, silver, and aluminum," Trans. Am. Inst. Min., Metall. Pet. Eng., 233, 1438-1439 (1965).
4. H. S. Chen and D. Turnbull, "Thermal properties of gold—silicon binary alloy near the eutectic composition," J. Appl. Phys., 38, No. 9, 3646-3650 (1967).
5. G. A. Andersen, J. L. Bestel, A. A. Johnson, and B. Post, "Eutectic decomposition in the gold—silicon system," Mater. Sci, Eng., 7, No. 2, 83 (1971).
6. L. G. Khvostantsev, L. F. Vereschagin, and A. P. Novikov, "Device of toroid type for high pressure generation," High Temp. High Pressures, 9, No. 6, 637-639 (1977).
7. T. R. Anantharaman, H. L. Luo, and W. Klement, Jr., "Nonequilibrium structures in gold—germanium alloys," Trans. Am. Inst. Min., Metall. Pet. Eng., 233, 2014 (1965).
8. R. C. Krutenat, J. K. Tien, and D. E. Fornwalt, "Sputter deposition of a metastable phase in the Au—Si system," Metall. Trans., 2, 1479-1481 (1971).
9. A. Damask and J. Dins, Point Defects in Metals [Russian translation], Mir, Moscow (1966).
10. W. Klement, Jr., R. H. Willens, and P. Duwes, "Non-crystalline structure in solidified gold—silicon alloys," Nature (London), 187, No. 4740, 869-870 (1960).

ELECTROPHYSICAL INVESTIGATION OF THIN-LAYERED INORGANIC COATINGS

I. V. Kochugova, L. V. Nikolaeva, and N. M. Vakser

UDC 539.216.2

Miniaturization of electrotechnical devices which leads to lower volumes of materials and higher specific characteristics requires development of insulating thin-layer coatings. These should have a wide range of useful properties (pliability, heat stability, high specific resistivity, etc.). These properties should be maintained for long periods. Continuous thin glassy films in a number of cases are irreplaceable, however, they have a very substantial shortcoming: The electrical resistivity of such films at temperatures elevated to 400-600°C falls sharply [1].

The electrical resistivity of compositions can be raised by creation of coatings based on glassy binder and highly dispersed fillers, refractory oxides of aluminum, silicon, chromium, magnesium, etc. [2]. To this end, gelatinous solutions containing 40-65% of tetraethylorthosilicate (TEOS) as the glass-forming component and aqueous salt solutions as well as solutions containing orthophosphoric acid instead of TEOS as the glass-forming component are used.

M. I. Kalinin Leningrad Polytechnic Institute. Translated from Izvestiya Akademii Nauk SSSR, Neorganicheskie Materialy, Vol. 25, No. 6, pp. 981-983, June, 1989. Original article submitted May 12, 1987.

0020-1685/89/2506-0826$12.50

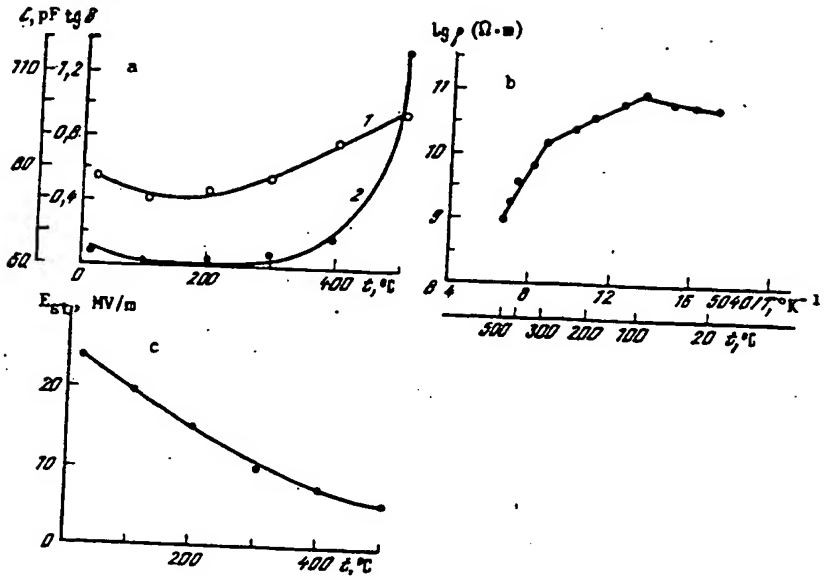

Fig. 1. Temperature dependence of tan δ (1) and capacitance (2) (a), specific electrical resistivity (b), and dielectric strength (c) for a sample of inorganic coating on Ni consisting of the nitrate glassy binder with Cr_2O_3 filler.

Inorganic coatings (IC) which are prepared from suspensions consisting of powdered filler (50-60 mass %) ibuted in a dispersing medium, a solution which forms a glassy-matrix coating upon firing, are studied. These ices bind the filler.

The inorganic compositions were studied through the composition of the salts used (nitrates and acetates), filler Al_2O_3, Cr_2O_3), coating thickness, firing temperature, and binding by various substrates (Al, Ni, stainless steel, and rome)

Characteristics of the oxide powders used as filler were: α-Al_2O_3, M-24 grade, content of impurities (mass %) 0.1 Fe_2O_3, less than 1 SiO_2, less than 0.6 Na_2O, dispersivity 1-2 μm; and Cr_2O_3, pure grade, dispersivity, 1-3 μm.

Dielectric characteristics were measured (tan δ and capacitance C) at a frequency of 1 kHz, resistance to direct nt and electrical stability in a practical frequency field between 20-500°C. In this case, standard methods and ments and silver electrodes were used. The measurements were done on 5-10 samples of each material. Figure es the average values. The variation coefficient in all cases did not exceed 10%.

Figure 1 gives the experimental data for a coating on nickel consisting of the nitrate binder and Cr_2O_3 filler. lysis of these revealed the nature of dielectric loss and conductivity as well as the change of basic electric insulating erties with temperature change.

Lowering of tan δ and C between 20-150°C is related to removal of adsorbed water. Further, as the sample is d the polarization processes are strengthened. This apparently is explained by the migration of charges accumulated interface of the matrix and the inclusions.

For revealing the nature of dielectric losses, tan δ was calculated according to an equivalent parallel scheme of ric replacement [3], tan $\delta_{calc} = 1/\omega CR$, where ω is the circular oscillation frequency, C is the sample capacitance, is the direct current resistivity.

Results of the calculation showed a difference of tan δ_{exp} vs. tan δ_{calc} over the whole temperature range. quently, the increased losses with temperature are explained both by conductivity and by polarization.

The temperature dependence of log ρ_v is a straight line with breaks, i.e., the electrical resistivity depends on rature by a stepped law. The portion of elevated resistivity with heating from 20 to 100°C is related to the val of adsorbed water. The values of activation energy of conductivity between 100-300°C and higher are 0.1- nd 1.0-1.1 eV, respectively.

Electrical stability falls smoothly as the temperature is increased.

The main parameters which affect the properties of the inorganic coating were ascertained for optimization of mposition (Fig. 2).

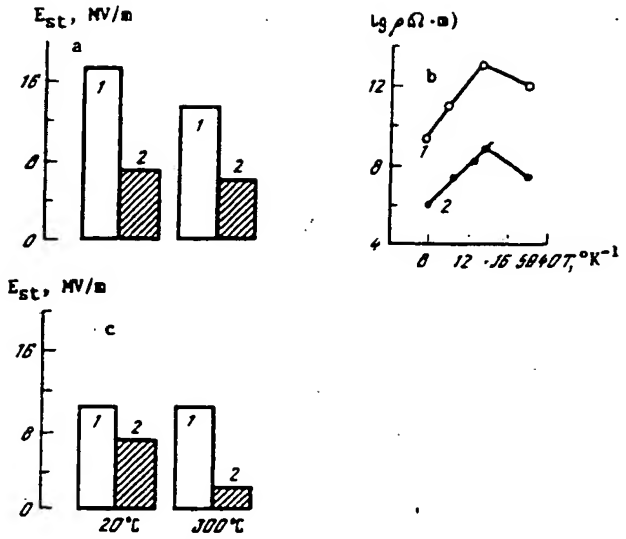

Fig. 2. Dielectric strength of coatings based on nitrate (1) and acetate (2) glassy binders at 20 and 300°C (a), temperature dependences ρ of coatings filled with corundum (1) and Cr_2O_3 (2) (b), and dielectric strength of coatings on Ni (1) and stainless steel (2) at 20 and 300°C (c).

The use of corundum as filler is seen to increase the electrical resistivity over a wide temperature range. It is axiomatic that the acetates have a lower level of E_{st} by comparison to the nitrate glassy binders. The reason for this lowering of electrophysical properties of the acetate compositions is the decomposition of the acetate anion into volatile components at 400-500°C. In this case, the possible appearance of impurities of highly dispersed carbon in the composition is not excluded. Oxidation of this prevents the formation of an amorphous glass film on the surface.

The electrical resistivity increases with increased firing temperature: it is $4.3 \cdot 10^{10}$ and $1 \cdot 10^7$ Ω·m for the nitrate coating on nickel with corundum filler at 20 and 300°C after firing at 400°C, and $1.3 \cdot 10^{14}$ and $1 \cdot 10^9$ Ω·m after firing at 500°C.

An increase of the coating thickness on one hand improves the electrical properties due to a decreased probability of entrance of permeable defects. On the other, the elasticity and pliability of the coating is decreased.

The properties of the coatings depend on the substrate material since the product of interaction of the oxide layer and the inorganic binder is a part of the coating.

It should be noted that the most effective glassy solutions can be used for preparation of thin-layered insulator on pliable conductors. The glassy binder in the ceramic layer is formed directly on the coated surface. The coating process on the pliable conductor is done continuously and is fixed by firing at 500-700°C.

CONCLUSIONS

Inorganic coatings placed on a metal base as a thin layer (20-25 μm) combine good electrical insulating properties with pliability and elasticity.

The dielectric losses in the compositions studied are defined by conductivity and polarization. They grow with heating.

The properties of the coatings, prepared from a suspension of filler in a glass-forming solution, depend mainly on the nature of filler and can change substantially with exchange of one filler by another.

LITERATURE CITED

1. I. B. Peshkov, Coated Wires [in Russian], Énergoatomizdat, Moscow (1983).
2. A. I. Borisenko and L. V. Nikolaeva, Thin-layered Glass-enamel and Glass-ceramic Coatings [in Russian], Nauka, Leningrad (1970).
3. N. P. Bogoroditskii, V. V. Pasynkov, and B. M. Tareev, Electrotechnical Materials [in Russian], Énergoatomizdat, Leningrad (1985).

INOMAF 25(6) 747-892 (1989)

ISSN 0020-1685

Russian Original Vol. 25, No. 6, June, 1989

November, 1989

INORGANIC MATERIALS

ИЗВЕСТИЯ АКАДЕМИИ НАУК СССР — НЕОРГАНИЧЕСКИЕ МАТЕРИАЛЫ

(IZVESTIYA AKADEMII NAUK SSSR — NEORGANICHESKIE MATERIALY)

TRANSLATED FROM RUSSIAN

C/b CONSULTANTS BUREAU, NEW YORK